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Estimation of loads for off-grid solar photovoltaic systems

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ABSTRACT

Solar power is a renewable energy technology that turns sunlight into electricity using solar panels. The generated electricity can be stored or utilized immediately, returned to the grid, or combined with a renewable electricity source or several renewable technologies solar energy systems are a supply that is both dependable and environmentally friendly of energy that may be used for a range of applications, including commercial, industry, farming, and livestock needs. The system requires practically no maintenance, making it perfect for isolated locations. The near-zero operating costs outweigh the initial hefty installation costs. When evaluated at an ambient temperature of 25 °C, a typical photovoltaic (PV) module outputs power with a maximum output voltage of roughly 17 V. However, on a very warm day, it can drop to around 15 V, and on a very freezing day, it can drop to around 15 V, it can soar to 18 V.

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1. INTRODUCTION

Every year, the sun emits 3.81024 joules of photonic radiation is the emission of energy. via the Earth's atmosphere. This corresponds to around 10,000 times our current annual energy use [1], [2]. The amount of solar energy received at a place is determined by its location, time of day, and weather. Understanding a site's solar resource is critical because it determines the photovoltaic (PV) array's needed capacity [3]. The power generated by sunshine is measured in watts per square meter and is known as "irradiance" Figure 1. depicts the average irradiance over the world as a solar resource map. The insolation is a single measurement that most succinctly, but not totally, describes a location's solar resource [4]. This is not to be confused with the term "insulation." The energy provided by sunshine per unit area over time is known as insolation [5]. Kwh of electricity hours per sq.m per day (kWh/m^2) or kWh/m^2 per year (kWh/m^2). are standard units of measurement. When averaged over a year, insolation varies substantially, ranging from 3.5 to 6.0 kWh/m^2/day [6]. The difference in insolation from month to month might be significant. This is particularly obvious in areas with long rainy seasons or those that are far from the equator [7].

2. CONFIGURATION OF A TYPICAL OFF-GRID PV POWER SYSTEM

Off-grid PV energy packages can varied in diameter from a single component, trickle charger system for powering grid current PV cells with hundreds of kW, a huge an inverter, and a battery bank (or inverters)for delivering ac power to the load can be found in a modest home to a big organization with hundreds of kW of PV modules, a large battery bank, and an amplifier for delivering ac power to the load. A hydrocarbon or

biofuels generation may be included in larger systems [8]. The construction of Pv plant mixed power systems is covered in a second guidelines titled development of Pv plant hybrid power grids.The configuration of a system that only produces direct current (DC) power [9] as shown in Figure 2. These systems are commonly seen in rural dwellings and village meeting houses, where DC electricity is used to power lights and tiny DC or ac equipment, each of which is powered by its own dedicated converter that runs on DC power. Solar installations typically range from 100 to 1000 watts per square meter, while smaller or larger installations are feasible. 12 V, 24 V, and 48 V DC voltage are commonly used to power loads. A residential solar system (RSS) is a type of installation that is widely used to power up remote beach towns [10], [11].

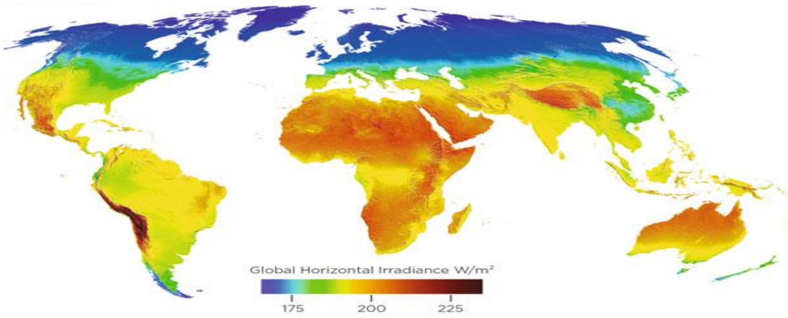

Figure 1. A map of the world's solar resources, showing average irradiance

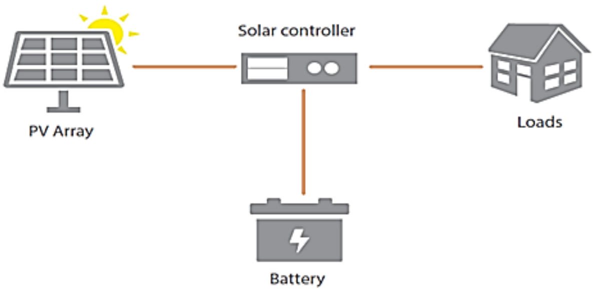

Figure 2. Only DC loads are powered by this arrangement

3. COMPONENTS OF PV SOLAR SYSTEMS

Based on the system type, site location, and purposes, individual aspects of a solar Power system should be selected. A solar PV system's fundamental parts are the solar controller, renewable energy inverter, storage battery, extra power sources, and loads. Sunlight is converted into DC power by a solar panel. A solar regulators controls the current and voltage sent to the storage by the PV array limiting overspending & increasing batteries life. A solar power inverter is a device that converts the Converting the Output waveform to a stable AC current from solar farms It can be used in air conditioners or transferred to the power grid A battery is a type of energy storage device that stores energy to be utilized to power electrical devices when it is needed. Lights are referred to as a load. and other electronic equipment coupled to a solar PV system, radios, televisions, laptops, and refrigerators. Diesel generators or other renewable energy sources can be used as auxiliary energy sources.

4. SIZING A PHOTOVOLTAIC (PV) SYSTEM

Determine the amount of energy required. Calculating the overall energy requirements of all applications is the first stage in installing a solar PV system that the solar PV system must power. Calculate the total number of watt-hours by each equipment every day. To determine the total Watt-hours per day that can be provided to the products, add the Watt-hours required for all equipment collectively [12]. Estimate how several total Watt-hours the solar system produces every day. panels must generate [13]. To get the electricity Is produced per day that the panels must provide, divide the total equipment Watt-hours per day by 1.2 [14].

5. SIZING OF SOLAR POWER INVERTERS

In systems that require AC power output, An converter for solar electricity is utilized [15]. The renewable power inverter's input capacity must always be more than the hardware's total energy a nominal voltage of the solar power inverter and the battery must be the same [16]. The solar power inverter for stand-alone systems must be capable of handling the whole quantity of Watts you will be using at any given moment [17].

6. SIZING OF PV SOLAR SYSTEM BATTERIES

Deep cycle batteries are the sort of battery that is used for long periods of time. It is recommended for use in photovoltaic solar systems [18]. A long period of time After being discharged, batteries are designed to be swiftly recharged. Dropped to a lower energy state, or cycle charged and depleted for years at a time. The charger must have enough capacity to store enough energy for the appliances to work overtime and on overcast days [19].

7. SIZING OF SOLAR REGULATORS

The amperage and voltage of a solar regulator are commonly specified [20]. Select a solar regulator that matches evaluate the voltages of your PV array and storage, then choose the best option. Model is appropriate for your needs. Make that the solar regulator is enough to handle the electricity produced by the PV array [21]. The PV panel configuration, as well as the overall PV input current sent to the controller, define the controller size for a series charge controller (series or parallel configuration) [22].

8. CHARGE CONTROLLERS WITH MAXIMUM POWER POINT TRACKING

In controllers, the method of collecting the maximum power output from a photovoltaic module under certain conditions [23]. The level at which a Solar panel can create so much electricity is known as its mpp (or peak power voltage) [24]. Sun irradiation, weather conditions, and solar energy temperature all influence maximum power. When evaluated at a module temperature of 25 °C, a typical PV module produces electricity with a max power voltage of roughly 17 V; but, on a very hot day, it can drop to just over 15 V, and on a very cold day, it can fly to 18 V [25].

9. SOLAR POWER SYSTEM CALCULATIONS

Solar panels: We performed the required electrical calculations for the solar panels and it was as follows:

9.1. Power consumption demands

The load demand is taken to be 1000W.

a. Total watt-hours per day = power * no.of hours / day

$$= 1000 \times 24$$

= 24000 wh

b. Required watt-hours each day from PV modules = total watt - hours * 1.2

$$= 24000 \times 24$$

= 28800wh / day

c. Total wp of PV panel capacity $= \frac{watt-hours/day}{pv\ generation\ factor}$

$$= \frac{28800}{5.0}$$

= 5760 wp

d. No. of panel $= \frac{total\ wp}{wp\ of\ panel}$

$$= \frac{5760}{175} = 32.9$$

The total number of panels is therefore 33.

Total module wattage = no. of panels * panel wp

$$= 33 \times 175 = 5775\ wp$$

Maximum system current = I_{mpp} * no. of module parallel strings
Where I_{mpp} is the maximum panel current
$= 4.89 \times 33 = 161.37\ A$

9.2. Inverter sizing

Total energy is multiplied by 1.25 to determine the size of the inverters. For self-contained systems, the inverter must be 25% to 30% larger than the total wattage of the equipment.

$$inverter = 1000 * 1.25 = 1250\ w$$

9.3. Battery sizing

In calculations, we estimated that the load would consume electricity for 24 hours.
Load: 1000 w
Hours: 24 hrs
Total watt - hours per day $= 1000 * 24 = 24000\ w\ h$/day
Bttery power losses are estimated to be 10%.
The discharge depths: 50%
Rechargeable bank derating for air conditions

Choosing deep cycle devices to fulfill ampere-hour potential: To get 24 V, join different 12 V batteries in series. When batteries are interconnected, their Ampere-hour capacity does not augment; it is simply additive. Using 12V, 210Ah rechargeable lithium batteries

$$no\ of\ parallel\ strings = \frac{battery\ bank\ Ah\ capacity}{battery\ Ah}$$
$$= \frac{6666.7}{210} = 31.7 = 32 \text{ strings}$$

No. of batteries in bank = no.of series string*batteries per string
=32*2 =64 batteries

9.4. Solar regulator sizing

Solar panel specification:

Power (P_m)	=175 W_p
voltage (V_{mpp})	=35.8 V
current (I_{mpp})	=4.89 A
voltage in an open circuit (V_{oc})	= 44.4 V
current with a short circuit (I_{sc})	= 5.30 A
nominal voltage of the charger	= 24 V

$V_{pmsystem} = V_{pmmodule}$ * no. of module in series
= 35.8*1=35.8 V

$V_{ocsystem} = V_{ocmodule}$ * no. of modules in series
= 44.4*1=44.4 V

The recharge controller's value of current will have to manage determines the size of the charge controller.

P = v*I

The total amount of power generated by the modules is 5775 W, the bank of batteries is 24 V

$$I = \frac{power}{volts} = \frac{5775}{24} = 240.625 \text{ A}$$

A 25% premium is applied to the value to account for unusual circumstances that may cause it is possible for a solar panel arrangement to produce more energy than it is rated for.

I_{tot} = 240.625 A + 25%
= 300.78^{a}

In this situation, 80 chars, the current is significantly greater than the charge controllers can manage.

$$\text{No of charge controllers} = \frac{\textit{total current}}{\textit{maximum cureent}\backslash\textit{controller}}$$

$$= \frac{300.78}{80} = 3.7$$

The chargers requested are 4 if the value above is rounded off.

10. THE SIMULATION OF MAXIMUM POWER POINT TRACKING

When it comes to maximizing power extraction from PV sources, there are usually two basic ways. The solar panel's mechanical tracking is the initial step. On this scenario, the panel is positioned in any terrain at a ninety-degree angle to the path of the incoming sun ray. The MATLAB/Simulink/Simpower PV simulation system Figure 3 depicts this. Simulation resulted of PV panel characteristics shown in Figure 4.

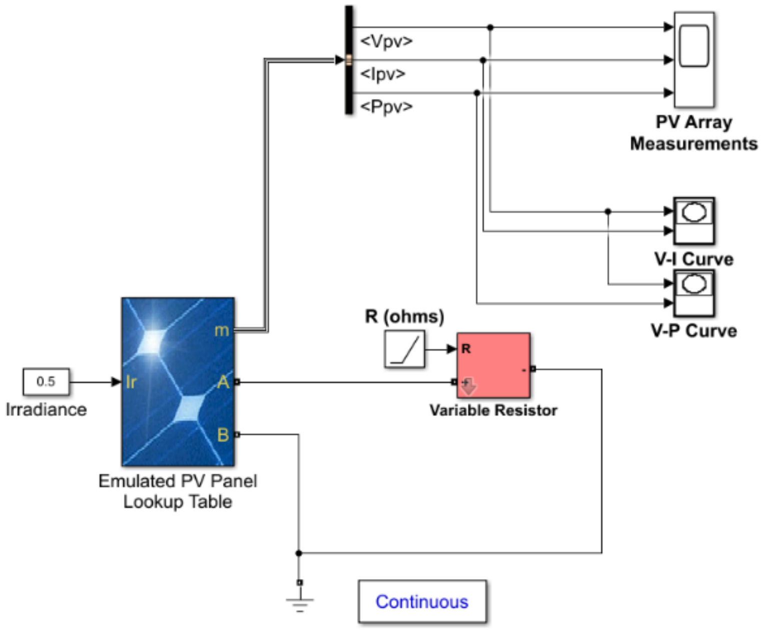

Figure 3. The PV and MATLAB/Simulink/Simpower PV simulation system

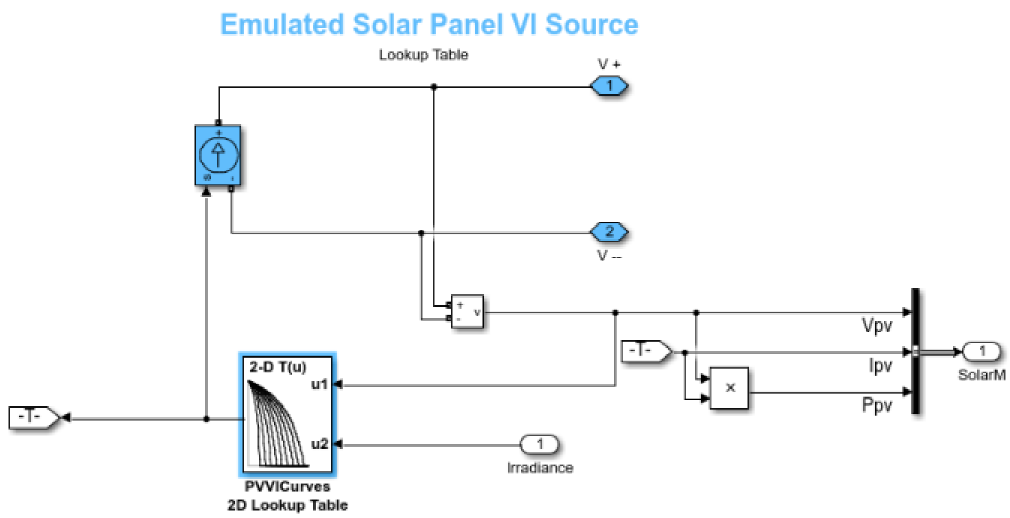

Figure 4. Simulation resulted of PV panel characteristics

Figure 5 shows at varying irradiance conditions, solar arrays' voltage-current (V-I) and wattage (V-P) characteristics as a function of irradiance Because the current created by the light is proportional to the amount of light generated, created by the flow of photons, the PV cell produces larger output currents under higher irradiance, as shown in Figure 5. As irradiation drops, the max power point (MPP) lowers, as seen on each (V-P) curves in the chart Figure 6. We note through the figures the relationships between voltage and time as in Figure 7 and the relationship between current and time as in Figure 8 and the relationship between power and time as in Figure 9

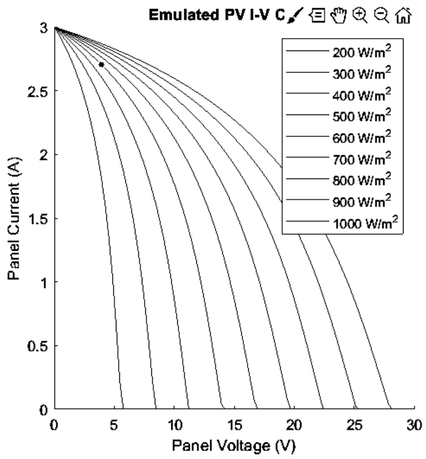

Figure 5. Current solar panels' properties at varying irradiation levels

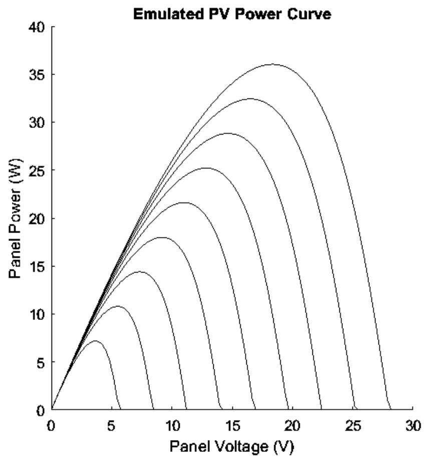

Figure 6. Power solar panels' properties at varying irradiation levels

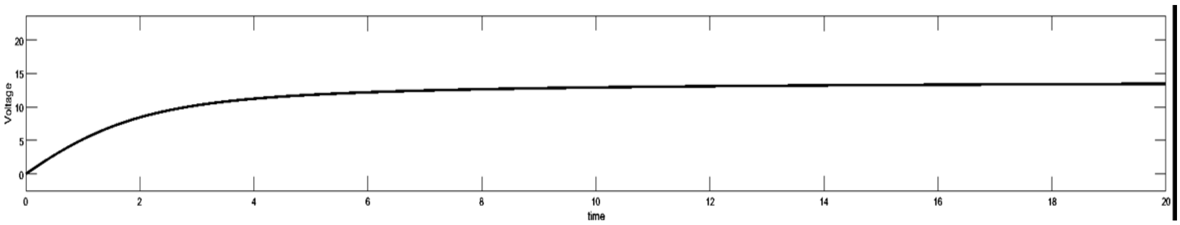

Figure 7. Voltage and time are related

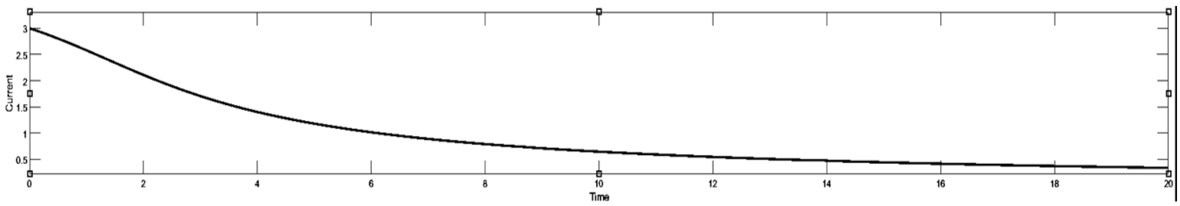

Figure 8. Relation between current and time

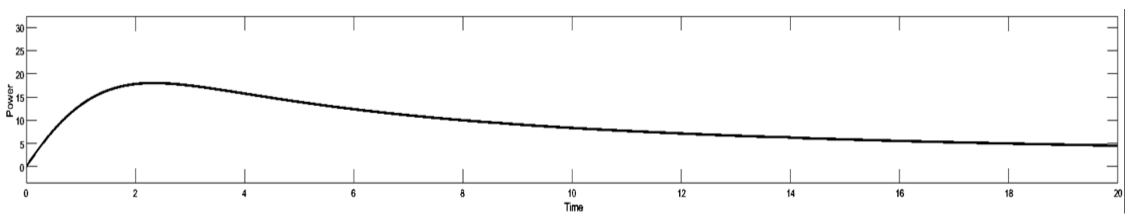

Figure 9. Relation between power and time

11. CONCLUSION

Based on the different calculations, we can conclude that we can choose an integrated solar energy system with minimal losses and optimal use so that the batteries last as long as possible. The system can also be developed by adding a hybrid inverter and lithium batteries because its life span is longer and solar panels.

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